# English Translation of Reference 3

## PATENT ABSTRACTS OF JAPAN

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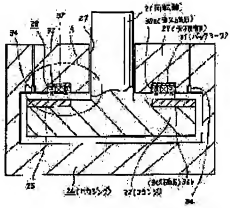
(54) MAGNETIC BEARING DEVICE

(57)Abstract:
PURPOSE: To secure a large load capacity while the power consumption is minified during the operation by applying the large magnetic force between the end face in the magnetizing direction of a permanent magnet and a flange, and connecting the end faces on the opposite side to each other by a back yoke.
CONSTITUTION: A magnetic bearing unit 28 is provided with a pair of permanent magnets 30a, 30b, a back yoke 31, and a magnetizing coil 32. When a rotary shaft 2 is tilted downward, an auxiliary magnetic circuit is formed in the magnetic bearing unit 28 by energizing the magnetizing coil 32 in the prescribed direction. In this condition, the magnetic attraction based on the auxiliary magnetic circuit is added to the magnetic attraction to be applied between the permanent magnets 30a, 30b and a ferromagnetic steel sheet 25. Thus, the magnetic attraction to be applied between the magnetic bearing unit 28 and the steel sheet 25 is increased to prevent a rotary shaft 2. On the contrary, when the rotary shaft 2 is tilted upward, the magnetic attraction is reduced by energizing the magnetizing coil 32 in the reverse direction to prevent the rotary shaft 2 from being elevated.



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2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

## DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]For example the magnetic bearing device concerning this invention changes surplus electric power at night into kinetic energy, stores it, and it is used for it in the state where it included in various ultra high-speed rotary machine devices, such as a superconductivity flywheel device which constitutes the stationary energy storage apparatus which changes this kinetic energy into electrical energy, and takes it out in the daytime.
[0002]
[Description of the Prior Art]As a device which installs in a small-scale place of business or an ordinary home, and can store surplus electric power at night, a flywheel with a big moment is fixed to the axis of rotation, and the stationary energy storage apparatus which attached the dynamo combination motor to this axis of rotation is studied. In the case of this stationary energy storage apparatus, by supplying surplus electric power to the above-mentioned dynamo combination motor at night, the above-mentioned axis of rotation and a flywheel are rotated, the above-mentioned surplus electric power is changed into kinetic energy, and it stores as rotational kinetic energy of a flywheel. And based on this rotational kinetic energy, it generates electricity by the above-mentioned dynamo combination motor, and electric power is taken out and used for daytime.
[0003]In order to raise the efficiency of the stationary energy storage apparatus which uses such a flywheel, it is necessary to use the thing which has the few energy which operation moreover takes and which has little rotational resistance as a bearing device for carrying out rotation support of the above-mentioned flywheel. For this reason, from the former, the stationary energy storage apparatus which uses a superconductivity magnetic bearing device as a bearing device is proposed as indicated to JP,5-248437,A. Drawing 14 shows the stationary energy storage apparatus incorporating the superconductivity magnetic bearing device indicated in this gazette.
[0004]The axis of rotation 2 is allocated in the central part of the sealed vacuum housing 1 in the perpendicular direction. As the circumference of this axis of rotation 2 is surrounded in the inner surface of the above-mentioned vacuum housing 1, the holding pipe 3 is fixed to it. And each forms the active mold magnetic bearings 6 and 6 which comprise the magnetic rings 4 and 4 and the electromagnets 5 and 5 between the lower half part inner skin of this holding pipe 3, and the pars intermedia peripheral face of the above-mentioned axis of rotation 2, and positioning covering the radial direction of the above-mentioned axis of rotation 2 is aimed at. Between the Johan circles peripheral surface of the above-mentioned holding pipe 3, and the upper bed part of the above-mentioned axis of rotation 2, the dynamo combination motor 9 which comprises the rotor 7 and the stator 8 is formed.
[0005]The flywheel 10 which is a rotating member is fixed to the lower end part of the above-mentioned axis of rotation 2, and the circular permanent magnet 11 is fixed to the undersurface of this flywheel 10 at it. This permanent magnet 11 covers shaft orientations (sliding direction of drawing 14), and is magnetized.
It is being fixed to the center of the above-mentioned axis of rotation 2 and the same mind which are centers of rotation of the above-mentioned flywheel 10.
The cooling jacket 12 which serves as a holddown member is fixed to the bottom of the above-mentioned vacuum housing 1, and the upper surface of the superconductor 13 provided in the upper surface of this cooling jacket 12 is made to counter the undersurface of the above-mentioned permanent magnet 11. As for this superconductor 13, it is desirable to suppose that it is circular like the above-mentioned permanent magnet 11, and to arrange to this permanent magnet 11 and same mind. However, when it is difficult to build in a circle, each arranges two or more superconductors built by disc-like and circular ** at equal intervals on

the above-mentioned permanent magnet 11 and a concentric circle. In the above-mentioned cooling jacket 12, circulation of cooling agents, such as liquid nitrogen, is enabled, and the above-mentioned superconductor 13 is made to be made into a superconducting state. When the superconductor 13 is in a superconducting state, it is prevented by the pinning effect that the distance of this superconductor 13 and the above-mentioned permanent magnet 11 changes. Therefore, these superconductors 13 and the permanent magnet 11 constitute the noncontact superconductivity thrust magnetic bearing 14.

[0006]The operation of the conventional stationary energy storage apparatus constituted as mentioned above is as follows. When storing surplus electric power at night etc., said axis of rotation 2 and the flywheel 10 are rotated by supplying surplus electric power to the stator 8 of the dynamo combination motor 9. Under the present circumstances, by said activity type magnetic bearing 6, positioning covering the radial direction of the axis of rotation 2 is aimed at, and a cooling agent is sent in in the cooling jacket 12, and the superconductor 13 is cooled. If the superconductor 13 will be cooled and it will be in a superconducting state, the power in which the permanent magnet 11 prevents shaft orientations and moving radially to the superconductor 13 will act by what is called a pinning effect that the magnetic flux which came out of the permanent magnet 11 is restrained in the superconductor 13. The power of a thrust direction and the power of a radial direction of acting on the above-mentioned axis of rotation 2 and the flywheel 10 are supported movably by this power. Thus, where the active mold magnetic bearing 6 and the superconductivity thrust magnetic bearing 14 are operated, the above-mentioned axis of rotation 2 and the flywheel 10 are supported in the state of surfacing. therefore, the resistance to these both the members 2 and 10 rotating -- **** -- it becomes small.

[0007]Since the revolving speed of the axis of rotation 2 and the flywheel 10 rises gradually with the energization to the above-mentioned stator 8, where electric power is changed into mechanical movement energy, it can be stored. Since it is provided in the vacuum housing 1, the surface and air of a member to rotate do not rub each other, and unless electric power extraction by the above-mentioned dynamo combination motor 9 is performed, as for the axis of rotation 2 and the flywheel 10, almost falling of the revolving speed of the flywheel 10 which went up once is lost. In taking out and using the stored energy, it connects the above-mentioned stator 8 to load (electric installation) daytime etc. As a result, electric power is caused in the above-mentioned stator 8 based on rotational movement of the above-mentioned flywheel 10.

[0008]What was indicated in JP,2-87120,U and a 4-97119 gazette other than the conventional structure of the 1st example mentioned above as a magnetic bearing device which supports the axis of rotation which carries out a high velocity revolution in the state of surfacing is known. Drawing 15 shows the magnetic bearing device indicated to JP,2-87120,U of these. In this conventional structure of the 2nd example, the round ring shaped yokes 15a and 15b are fixed to the top-and-bottom-ends part of the axis of rotation 2 by the product made from a magnetic material, respectively. The magnetic bearing units 17a and 17b of one pair of upper and lower sides are fixed to the inner skin of the housing 16 surrounding these axes of rotation 2 and the yokes 15a and 15b. And the upper surface of the lower yoke 15b and the undersurface of the lower magnetic bearing unit 17b are made for the undersurface of the upper yoke 15a and the upper surface of the upper magnetic bearing unit 17a to counter via a bearing gap, respectively.

[0009]Each above-mentioned magnetic bearing units 17a and 17b are provided with the circular permanent magnet 18 magnetized by shaft orientations (sliding direction of drawing 15), respectively, and the back yoke 19 built with section J type cylindrical by the magnetic material. The circular magnetization coil 20 is dedicated in the space which had the three way type surrounded by this back yoke 19, and magnetization of this back yoke 19 is enabled. The lower end surface of the above-mentioned axis of rotation 2 is made to counter, the position transducer 21 is formed, and the axial position of this axis of rotation 2 is made flexibly detectable.

[0010]The above-mentioned axis of rotation 2 is supported in the state of surfacing based on the magnetic attraction power of the permanent magnets 18 and 18 built into each above-mentioned magnetic bearing units 17a and 17b with this conventional structure of the 2nd example. Since the magnetic attraction power of these each permanent magnets 18 and 18 is unstable, the above-mentioned axis of rotation 2 is displaced to shaft orientations as it is. Based on the detecting signal of the above-mentioned position transducer 21, then, each above-mentioned magnetic bearing unit 17a, A direct current of a predetermined size is passed to the magnetization coils 20 and 20 built into 17b in a determined direction, the magnetic attraction power of these each magnetic bearing units 17a and 17b is adjusted, and the above-mentioned axis of rotation 2 is prevented from being displaced to shaft orientations.

[0011]Drawing 16 shows the magnetic bearing device indicated to JP,4-97119,U. The flange 22 made from a magnetic material is fixed to the pars intermedia peripheral face of the axis of rotation 2, and the magnetic bearing unit 23 is made to counter up-and-down both sides of this flange 22 in this conventional structure of the 3rd example. The one yoke 24 in which the whole was formed for the section in a circle by approximately C type as for this magnetic bearing unit 23, It has one pair of magnetization coils 20a and 20a provided between one pair of permanent magnets 18 and 18 which it is annexed to the both ends of this yoke 24, and like poles were made to counter mutually, and these permanent magnets 18 and 18 and the pars intermedia of the above-mentioned yoke 24.

[0012]The above-mentioned axis of rotation 2 is supported in the state of surfacing based on the magnetic attraction power of the permanent magnets 18 and 18 built into the above-mentioned magnetic bearing unit 23 with this conventional structure of the 3rd example. When the above-mentioned axis of rotation 2 is displaced to shaft orientations (sliding direction of drawing 16), Based on the detecting signal of the position transducer which is not illustrated, a direct current of a predetermined size is passed to each above-mentioned magnetization coils 20a and 20a in a determined direction, the magnetic attraction power of this magnetic bearing unit 23 is adjusted, and the above-mentioned axis of rotation 2 is prevented from being displaced to shaft orientations.

[0013]

[Problem(s) to be Solved by the Invention]By the way, when weight of the flywheel 10 is enlarged in order to raise the stationary-energy-storage capability of the stationary energy storage apparatus which is constituted as mentioned above, for example and acts (heavily), it is necessary to enlarge load carrying capacity of said superconductivity thrust magnetic bearing 14. Also when supporting big thrust loading added to the axis of rotation of various mechanical apparatus, too big load carrying capacity is needed. However, there is a limit in the load carrying capacity of the usable superconductivity thrust magnetic bearing 14 in the actual condition, It was difficult to plan improved efficiency of a stationary energy storage apparatus using the flywheel 10 which can be supported only by the superconductivity thrust magnetic bearing 14, or to support the axis of rotation in which big thrust loading is added.

[0014]The structure shown in drawing 15 - 16 can obtain sufficient load carrying capacity, if a big thing is used as the permanent magnet 18 and the magnetization coils 20 and 20a. However, it not only must enlarge these permanent magnets 18 and the magnetization coils 20 and 20a, but [ in order to obtain sufficient load carrying capacity, ] in the structure shown in these drawing 15 - 16, since the energizing amount to the magnetization coils 20 and 20a also increases, operation cost will increase. When it includes in a stationary energy storage apparatus, in order to consume the portion of many of the electric power which can be stored by operation of a magnetic bearing device, it becomes for example, less realistic.

[0015]That is, in the case of the structure shown in drawing 15, the upper magnetic bearing unit 17a gives the power of the direction of reduction to the lower magnetic bearing unit 17b giving the power of the raising direction to the axis of rotation 2. Therefore, in order to secure the load carrying capacity as the whole magnetic bearing device, magnetic attraction power of the magnetic bearing unit 17b of the above bottom is enlarged enough at least, and it is always necessary to continue sending current through the magnetization coil 20 which moreover constitutes this magnetic bearing unit 17b. As a result, power consumption increases.

[0016]In the case of the structure shown in drawing 16, the axial position of the axis of rotation 2 is regulated by balance of the magnetic attraction power of the permanent magnets 18 and 18 of one pair of upper and lower sides, but many of the lines of magnetic force which came out from the end face of these each permanent magnets 18 and 18 flow through the yoke 24, and do not contribute to surfacing of the above-mentioned axis of rotation 2. Therefore, in order to surface the axis of rotation 2, it will be necessary to make large enough the energizing amount to the magnetization coil 20a, and power consumption will increase too. The magnetic bearing device of this invention is invented that such inconvenience should be canceled.

[0017]

[Means for Solving the Problem]A magnetic bearing device of this invention is provided with the following.

Axis of rotation.

A flange provided in a part of this axis of rotation at this axis of rotation and same mind.

A ferromagnetic part of this flange provided in shaft-orientations one side at least.

Housing which has an internal surface which counters this ferromagnetic part, and surrounds the above-mentioned flange, A displacement sensor which counters at least one side of the above-mentioned flange, is formed in a part of this housing, and detects an axial position of the above-mentioned flange to this housing,

A controller which controls energization to a magnetic bearing unit which countered the above-mentioned

ferromagnetic part and was provided in a part of internal surface of the above-mentioned housing, and this magnetic bearing unit.

[0018]And the above-mentioned magnetic bearing unit is provided with the following.
At least one pair of permanent magnets in which each was magnetized by opposite direction shaft orientations and mutually, and each has been arranged at the above-mentioned axis of rotation and the same mind.
A back yoke made from a magnetic material which connects the end faces of an opposite hand with the above-mentioned flange magnetically in the polarizing direction end face of a permanent magnet used as these pairs.
A circular magnetization coil arranged at at least one place of a part between the one above-mentioned pair of permanent magnets, a part of inner skin of a permanent magnet of the diametral direction inside of these one pairs of permanent magnets, and a part of a peripheral face of a permanent magnet of the diametral direction outside.
The above-mentioned controller controls an energizing amount and an energizing direction to the above-mentioned magnetization coil based on a detecting signal of the above-mentioned displacement sensor, and keeps an axial position of the above-mentioned flange constant.
[0019]
[Function]According to the magnetic bearing device of this invention constituted as mentioned above, it is stabilized and the axis of rotation in which weight increases can be supported. That is, since magnetic attraction power strong between a flange, the field which counters, and the ferromagnetic part of this flange in the polarizing direction end face of the permanent magnet used as a pair acts, the load carrying capacity as the whole magnetic bearing device is fully securable. When it becomes the tendency for the position of the flange to housing to change, based on the detecting signal of a displacement sensor, a controller controls the energizing direction and energizing amount to a magnetization coil, and the magnetic attraction power which acts between a magnetic bearing unit and the above-mentioned ferromagnetic part is adjusted. Therefore, the axial position of the above-mentioned axis of rotation is controllable.
[0020]
[Example]Drawing 1 – 2 show the first example of this invention. The flange 22 is formed in the lower end part of the axis of rotation 2 arranged in the perpendicular direction at the center of this axis of rotation 2, and the same mind. This flange 22 has inertial mass big enough so that it may function as a flywheel and big kinetic energy can be stored. The steel plate 25 is fixed to the upper surface periphery side half part of such a flange 22 by welding, shrinkage fitting, a screw clamp, adhesion, etc., and this steel plate 25 is used as the ferromagnetic part of the above-mentioned flange 22 at it. And the circumference of the flange 22 containing this steel plate 25 is surrounded with the housing 26 made from nonmagnetic materials, such as an aluminum alloy and concrete. The above-mentioned axis of rotation 2 is made to project out of this housing 26 through the circular hole 27 established in the center section of the top plate section 29 which constitutes this housing 26. The magnetic bearing unit 28 is fixed inside the circular crevice 33 formed in the undersurface of the above-mentioned top plate section 29 which is an internal surface of housing, and the undersurface of this magnetic bearing unit 28 and the upper surface of the above-mentioned steel plate 25 are made to counter it. The construction material of the axis of rotation 2 and flange 22 main part is not asked in particular, if only sufficient intensity is securable.
[0021]The above-mentioned magnetic bearing unit 28 is provided with the back yoke 31 and the magnetization coil 32 per piece with one pair of permanent magnets 30a and 30b, respectively. Each is formed in a circle, the permanent magnets 30a and 30b of these are magnetized by the opposite direction shaft orientations (drawing 1 – two sliding directions) and mutually, and each is arranged at the center of the above-mentioned axis of rotation 2, and the same mind. The above-mentioned back yoke 31 is built by the round ring shape by ferromagnetic material, such as a steel plate. And the upper surface which is similarly a polarizing direction end surface of the permanent magnet 30b of the diametral direction outside at an undersurface periphery slippage portion about the upper surface which is a polarizing direction end surface of the permanent magnet 30a of the diametral direction inside is dashed against the undersurface inner circumference slippage portion of this back yoke 31, respectively. Therefore, the polarizing direction end surfaces of these one pairs of permanent magnets 30a and 30b are magnetically connected with the above-mentioned back yoke 31. By winding a lead, the above-mentioned magnetization coil 32 is formed in a circle in the whole, and is arranged in the space of the part (part between one pair of permanent magnets) which has a

three way type surrounded by the undersurface of the above-mentioned back yoke 31, and the peripheral surface of the one above-mentioned pair of permanent magnets 30a and 30b.
[0022]On the other hand, the displacement sensors 34 and 34 are fixed to the undersurface plurality place of the above-mentioned top plate section 29, respectively, and distance between the undersurface of the above-mentioned top plate section 29 and Kamitsura of the above-mentioned steel plate 25 is made it flexibly detectable with these displacement sensors 34 and 34. The detecting signal of these each displacement sensors 34 and 34 is inputted into the controller which is not illustrated. And this controller controls the energizing amount and energizing direction to the above-mentioned magnetization coil 32 based on the detecting signal of each above-mentioned displacement sensors 34 and 34, and keeps constant the vertical position which is an axial position of the flange 22 which fixed the above-mentioned steel plate 25.
[0023]According to the magnetic bearing device of this invention constituted as mentioned above, by fixing the flange 22, it is stabilized and the axis of rotation 2 in which weight increases can be supported. That is, between the lower end surface of one pair of permanent magnets 30a and 30b which constitute the above-mentioned magnetic bearing unit 28, and Kamitsura of the steel plate 25 fixed to the upper surface of the above-mentioned flange 22, the main magnetic circuit shown in drawing 2 as the solid line alpha is formed. Since the one above-mentioned pair of permanent magnets 30a and 30b are mutually magnetized by the opposite direction and it is moreover made to flow through each of upper bed sides magnetically with the above-mentioned back yoke 31, the intensity of the magnetic flux which constitutes the above-mentioned main magnetic circuit becomes strong (magnetic flux density is highly) enough. Therefore, magnetic attraction power strong between the above-mentioned magnetic bearing unit 28 and the steel plate 25 acts, and the load carrying capacity as the whole magnetic bearing device can fully be secured.
[0024]When it becomes the tendency for the position of the flange 22 to said housing 26 to change by the above-mentioned axis of rotation 2 being displaced in the perpendicular direction, Based on the detecting signal of the displacement sensor 34, a controller controls the energizing direction and energizing amount to a magnetization coil, and the magnetic attraction power which acts between the above-mentioned magnetic bearing unit 28 and the steel plate 25 is adjusted. That is, the power which supports the above-mentioned axis of rotation 2 in the surfacing state becomes very unstable only with the magnetic attraction power which acts between the one above-mentioned pair of permanent magnets 30a and 30b, and the steel plate 25. For example, when the distance of the lower end surface of the one above-mentioned pair of permanent magnets 30a and 30b and the upper surface of the steel plate 25 is a predetermined value, If it assumes that the weight of the axis of rotation 2 containing the above-mentioned flange 22 grade and the magnetic attraction power by the one above-mentioned pair of permanent magnets 30a and 30b balance, When the above-mentioned distance is larger than the above-mentioned predetermined value, the one above-mentioned pair of permanent magnets 30a and 30b will not support the axis of rotation 2, but when the above-mentioned distance is smaller than the above-mentioned predetermined value on the contrary, the axis of rotation 2 has gone up, and the above-mentioned steel plate 25 will stick to the lower end surface of one pair of permanent magnets 30a and 30b.
[0025]On the other hand, in the case of the magnetic bearing device of this invention, Since the magnetic attraction power which acts between the above-mentioned magnetic bearing unit 28 and the steel plate 25 can be adjusted by energization to the above-mentioned magnetization coil 32, the axial position of the above-mentioned axis of rotation 2 is controllable (the distance of the upper surface of the steel plate 25 and the undersurface of the magnetic bearing unit 28 is maintained to a predetermined value). That is, the submagnetic circuit shown in the above-mentioned magnetic bearing unit 28 with the broken chain line beta by energization to the above-mentioned magnetization coil 32 at drawing 2 is formed. Direction and strength (magnetic flux density) of the magnetic flux which constitutes this submagnetic circuit can be adjusted with the direction and size of a direct current which are passed to the above-mentioned magnetization coil 32.
[0026]So, when the above-mentioned axis of rotation 2 becomes a bearish tendency, the magnetic flux of said main magnetic circuit and the direction is passed to the above-mentioned submagnetic circuit by energizing to the above-mentioned magnetization coil 32 in a determined direction. In this state, it will be in the state where the magnetic attraction power based on the above-mentioned submagnetic circuit was added to the magnetic attraction power which acts between the permanent magnets 30a and 30b and the steel plate 25. For this reason, the magnetic attraction power committed between the above-mentioned magnetic bearing unit 28 and the steel plate 25 becomes large, and descent of the above-mentioned axis of rotation 2 is prevented.
[0027]On the contrary, when the above-mentioned axis of rotation 2 begins to rise, to the above-mentioned

magnetization coil 32, the above-mentioned determined direction is energizing to an opposite direction, and the magnetic flux of said main magnetic circuit and an opposite direction is passed in the above-mentioned submagnetic circuit. In this state, it will be in the state where the magnetic attraction power based on the above-mentioned submagnetic circuit was pulled from the magnetic attraction power which acts between the permanent magnets 30a and 30b and the steel plate 25. For this reason, the magnetic attraction power committed between the above-mentioned magnetic bearing unit 28 and the steel plate 25 becomes small, and a rise of the above-mentioned axis of rotation 2 is prevented.

[0028]In the case of the magnetic bearing device of this invention, the weight of the axis of rotation 2 containing flange 22 grade is supported with the magnetic attraction power generated in the main magnetic circuit formed mainly between one pair of permanent magnets 30a and 30b, and the steel plate 25. And when the balance of these weight and magnetic attraction power collapses, energizing to the magnetization coil 32 is only until it recovers this balance. Therefore, there are few energizing amounts to the above-mentioned magnetization coil 32, and they end, and the energy consumption at the time of operation of a magnetic bearing device becomes small.

[0029]Although radial bearing provided between the axis of rotation 2 and the housing 26 is omitted in the example mentioned above, noncontact radial bearing can also be provided between the inner skin of the circular hole 27 and the peripheral face of the axis of rotation 2 which were formed in the top plate section 29, for example. As noncontact radial bearing, a well-known magnetic bearing or fluid bearing (a pressured [ statically ] type, a dynamic pressure type) can be used from the former. Since the radial road added to the above-mentioned axis of rotation 2 is small, the energy consumption of radial bearing is small.

[0030]Next, drawing 3 - 4 show the second example of this invention. The magnetic bearing units 28a and 28b which are 2 sets from which a diameter differs in the case of this example are fixed to the undersurface of the top plate section 29 which constitutes the housing 26 at the axis of rotation 2 and the same mind, respectively. And the undersurface of each magnetic bearing units 28a and 28b and the upper surface of the steel plate 25 fixed to the upper surface of the flange 22 are made to counter. Therefore, magnetic attraction power which acts between these each magnetic bearing units 28a and 28b and the steel plate 25 is enlarged compared with the case of the first example mentioned above, and bearing of the axis of rotation 2 in which weight increases more is attained. The permanent magnet 30b of the diametral direction outside which constitutes the magnetic bearing unit 28a of the diametral direction inside, Magnetic flux is prevented from magnetizing in the direction and flowing among the polarizing direction end faces of these both the magnets 30a and 30b in the permanent magnet 30a of the diametral direction inside which constitutes the magnetic bearing unit 28b of the diametral direction outside. Other composition and operations are the same as that of the first example mentioned above.

[0031]Next, drawing 5 - 6 show the third example of this invention. In the case of this example, the magnetic bearing unit 28 and the second magnetic bearing unit 35 arranged so that this magnetic bearing unit 28 may be supported from under are formed on the undersurface of the top plate section 29 which constitutes the housing 26. Permanent magnet 30a' which constitutes the second magnetic bearing unit 35, and 30b' are magnetized in these each permanent magnets 30a and 30b and the direction which arrange on the diametral direction inside or the diametral direction outside of the permanent magnets 30a and 30b which constitutes the above-mentioned magnetic bearing unit 28, respectively, and adjoin it. And the upper bed sides of each above-mentioned permanent magnet 30a' and 30b' are magnetically connected with the second back yoke 36. And the second magnetization coil 37 is installed between the pars intermedia undersurface of this second back yoke 36, and the spacer 38 which following-**. Between the second magnetic bearing unit 35 and the above-mentioned magnetic bearing unit 28 which are constituted by this appearance, the spacer 38 made from a nonmagnetic material is pinched, and these both the magnetic bearing unit 35 and 28 comrades are magnetically intercepted in it.

[0032]It enlarges compared with the case of the second example mentioned above and the first example that mentioned above the magnetic attraction power which acts similarly between both the above-mentioned magnetic bearing units 35 and 28 and the steel plate 25, and bearing of the axis of rotation 2 in which weight increases more also of the case of this example is attained. In particular, in the case of this example, as the main magnetic circuit and the submagnetic circuit which are formed with the magnetic bearing unit 35 of the above second show drawing 6 at solid line alpha' and broken chain line beta', it reaches even at the portion which is distant from the undersurface of the top plate section 29. Therefore, even when the distance of the undersurface of this top plate section 29 and the upper surface of the steel plate 25 is large, load carrying capacity and bearing rigidity big enough can be acquired. Other composition and operations are the same as

that of the first example mentioned above.

[0033]Next, drawing 7 shows the fourth example of this invention. 3 sets of magnetic bearing units 28 and 28 are fixed to the undersurface of the top plate section 29 which constitutes the housing 26 in the case of this example. With this, the magnetic bearing of a rebounding type is provided between the undersurface of the flange 22, and the upper surface of the bottom plate part 39 which constitutes the above-mentioned housing 26, and load carrying capacity as the whole magnetic bearing device is enlarged enough. The unit 42a which comprises the two permanent magnets 40 and 40 and the one back yoke 41 which each was formed in a circle, and the magnetic bearing of the rebounding type of these covered shaft orientations (sliding direction of drawing 7), and were mutually magnetized by the opposite direction, It is fixing 3 sets of 42b at a time to the undersurface of the above-mentioned flange 22, and the upper surface of the bottom plate part 39, respectively. And the lower end surface of the permanent magnets 40 and 40 which constitute the units 42a and 42a fixed to the undersurface of the above-mentioned flange 22, and the upper bed side of the permanent magnets 40 and 40 which constitute the units 42b and 42b fixed to the upper surface of the above-mentioned bottom plate part 39 are made to counter by like poles mutually.

[0034]Therefore, in the case of this example, the weight of the axis of rotation 2 supports also according to the repulsive force which acts between not only magnetic attraction power but every 3 above-mentioned sets of units 42a which act between the 3 above-mentioned sets of magnetic bearing units 28 and 28, and the upper surface of the steel plate 25, and 42b. In the case of the example of a graphic display, the permanent magnet 40 and 40 comrades which constitute every 3 above-mentioned sets of units 42a and 42b have countered mutually in the state where it shifted to the diametral direction for a while. Therefore, among the end faces of these each permanent magnets 40 and 40, the repulsive force of a conical direction (direction which shifted to the diametral direction (longitudinal direction of drawing 7) for a while to shaft orientations) inclined to the axial center of the axis of rotation 2 acts. Therefore, the magnetic bearing of the above-mentioned rebounding type not only supports the weight of the above-mentioned axis of rotation 2, but has the function to aim at positioning of the radial direction of this flange 22. Therefore, if the load of a radial direction is small, it will also become possible to omit independent radial bearing. Supporting the weight of the above-mentioned axis of rotation 2 shall run short of the load carrying capacity of the magnetic bearing of this rebounding type, and the load carrying capacity running short is secured with the 3 above-mentioned sets of magnetic bearing units 28 and 28. Other composition and operations are the same as that of the first example mentioned above.

[0035]Next, drawing 8 shows the fifth example of this invention. This example carries out load of the magnetic bearing of a rebounding type to the structure of the third above-mentioned example. The structure of a suction type magnetic bearing and the operation which are provided in the flange 22 upper part among each magnetic bearing are the same as that of the third example mentioned above. The structure of the magnetic bearing of a rebounding type and the operation which are provided in the flange 22 bottom are the same as that of the fourth example mentioned above.

[0036]Next, drawing 9 shows the sixth example of this invention. In the case of this example, the superconductivity magnetic bearing 43 is formed between the undersurface of the flange 22, and the upper surface of the bottom plate part 39 which constitutes the housing 26, and load carrying capacity as the whole magnetic bearing device is enlarged enough. Since the superconductivity magnetic bearing 43 of these is constituted, in the undersurface of the above-mentioned flange 22. The permanent magnet units 46a and 46b which comprise the disc-like or circular permanent magnets 44a and 44b in which each covered shaft orientations (sliding direction of drawing 9), and was magnetized, and the back yokes 45a and 45b in which each was formed in disc-like or a round ring shape are fixed. The superconductor 47 is fixed to the upper surface of the above-mentioned bottom plate part 39, and cooling of this superconductor 47 is enabled with the cooling jacket which was provided in this bottom plate part 39 and which is not illustrated. And the undersurface of each above-mentioned permanent magnet units 46a and 46b and the upper surface of the above-mentioned superconductor 47 are made to counter mutually.

[0037]What is called pinning force to which it is supposed that the magnetic flux which flows between the lower end surfaces of the permanent magnets 44a and 44b which constitute each above-mentioned permanent magnet units 46a and 46b from superconductivity magnetic bearing 43 above-mentioned portion in the case of this example has been caught in the superconductor 47 works. This pinning force is resisting also to it being not only resisting, but going up to the above-mentioned flange 22 descending. For this reason, it becomes the resistance to superconductivity magnetic bearing 43 the very thing and the above-mentioned flange 22 being displaced to shaft orientations. As mentioned above, although this thing [ accepting it

superconductivity magnetic bearing 43, coming out, and obtaining required load carrying capacity ] is difficult, in being a magnetic bearing device of this invention, it supports the weight of the above-mentioned axis of rotation 2 also with the magnetic attraction power which acts between the steel plate 25 and the magnetic bearing units 28 and 28. Therefore, the load carrying capacity as the whole magnetic bearing device becomes large enough.

[0038]And although it cannot say that it is enough in the case of this example, since superconductivity magnetic bearing 43 the very thing is resisting to the axis of rotation 2 being displaced to shaft orientations, the displacement covering the shaft orientations of this axis of rotation 2 decreases. As a result, the frequency energized to the magnetization coils 32 and 32 which constitute each above-mentioned magnetic bearing units 28 and 28 decreases, and the power consumption at the time of magnetic bearing device operation decreases. The above-mentioned superconductivity magnetic bearing 43 not only supports the weight of the above-mentioned axis of rotation 2, but has the function to aim at positioning of the radial direction of the flange 22. Therefore, if the load of a radial direction is small, it will also become possible to omit radial bearing.

[0039]Next, drawing 10 shows the seventh example of this invention. In the case of this example, the body 48 was formed in the upper part of the housing 26, and the controlled type radial magnetic bearings [ two or more (the example of a graphic display two pieces) ] 49 and 49 and the one dynamo combination motor 9 are formed between the inner skin of this body 48, and the peripheral face of the axis of rotation 2. For this reason, in the case of this example, the rotors 50 and 7 cylindrical in the three peripheral face up-and-down position of the above-mentioned axis of rotation 2 at the product made from ferromagnetic material, such as steel, are fixed. The electromagnets 51 and 51 are fixed to the rotors 50 and 50 of top and bottom ends, and the portion which counters, respectively in the two inner skin up-and-down position of the above-mentioned body 48. These each electromagnets 51 and 51 comprise the electromagnet element quadrisected by the circumferencial direction, respectively. And the radial direction position of the above-mentioned axis of rotation 2 is regulated by energizing for which electromagnet element based on the signal from the displacement sensors 52 and 52 which countered the top-and-bottom-ends outside peripheral surface of the above-mentioned axis of rotation 2, and was established. The stator 8 is fixed to the portion between both the above-mentioned electromagnets 51 and 51 in the inner skin pars intermedia of the above-mentioned body 48, and the above-mentioned dynamo combination motor 9 is constituted with the above-mentioned rotor 7. In the case of this example, the radial bearing rigidity as the whole magnetic bearing device improves by forming the big controlled type radial magnetic bearings 49 and 49 of radial rigidity. Other composition and operations are the same as that of the fourth example mentioned above.

[0040]Next, drawing 11 shows the eighth example of this invention. In the case of this example, the flange 22 is formed in the pars intermedia peripheral face of the axis of rotation 2. And the controlled type radial magnetic bearings 49 and 49 are formed, respectively between the inner skin of the circular hole 53 formed between the Johan outside peripheral surface of the above-mentioned axis of rotation 2, and the inner skin of the body 48, and in the lower half part and the bottom plate part 39 of the axis of rotation 2. And he is trying to control the energization to these each controlled type radial magnetic bearings 49 and 49 by the detecting signal of the displacement sensors 52 and 52 which detect the displacement covering the radial direction of the top-and-bottom-ends part of the above-mentioned axis of rotation 2. The dynamo combination motor 9 is formed in the pars intermedia of the above-mentioned axis of rotation 2 between the directly under portion of the above-mentioned flange 22, and the inner skin of the above-mentioned circular hole 53.

[0041]In the case of this example, since the interval of the controlled type radial magnetic bearings 49 and 49 of one pair of upper and lower sides is large, the moment which prevents that the above-mentioned axis of rotation 2 inclines becomes large, and prevention from an inclination of this axis of rotation 2 can be aimed at more certainly. Other composition and operations are the same as that of the seventh example mentioned above.

[0042]Next, drawing 12 - 13 show the ninth example of this invention. In the case of this example, a section is KO type-like and the back yoke 31 counters the steel plate 25 and shaft orientations (drawing 12 - 13 sliding directions), the end face, i.e., the lower end surface, of radial (drawing 12 - 13 longitudinal directions) both sides of the back yoke 31. The polarizing direction end surface (drawing 12 - 13 upper bed sides) of one pair of permanent magnets 30a and 30b is in contact with the radial intermediate part of the back yoke 31, respectively. The part between one pair of permanent magnets 30a and 30b is space, and a nonmagnetic material. As shown to drawing 13 by the solid line alpha, three main magnetic circuits are formed in the magnetic bearing unit 28c which comprises one pair of permanent magnets 30a and 30b, the back yoke 31,

and the steel plate 25. Therefore, the main magnetic circuit in this example serves as strong magnetic flux.
[0043]In the case of this example, the circular magnetization coils 32 and 32 are allocated in the part between the inner skin of the permanent magnet 30a of the diametral direction inside, and the back yoke 31, and the part between the peripheral face of the permanent magnet 30b of the diametral direction outside, and the back yoke 31, respectively. Although energized in the direction to one pair of magnetization coils 32 and 32, If the energizing direction and energizing amount to one pair of magnetization coils 32 and 32 are controlled based on the detecting signal of the displacement sensor 34, the submagnetic circuit of magnetic flux stronger than the main magnetic circuit formed in the permanent magnets 30a and 30b will be formed in the back yoke 31 and the steel plate 25 as shown to drawing 13 by the broken chain line beta. Other composition and operations are the same as that of the first example mentioned above.
[0044]
[Effect of the Invention]Since it is constituted as stated above, and it acts, although there is little power consumption at the time of operation and it ends, the magnetic bearing device of this invention secures load carrying capacity big enough, and can support movably the big load added to a rotating part. Since the function to attenuate vibration of shaft orientations is also high, the mechanical apparatus incorporating a magnetic bearing device can be effectively prevented from vibrating at the time of operation.

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[Translation done.]

* NOTICES *



1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

## DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]Drawing of longitudinal section showing the first example of this invention.
[Drawing 2]The A section enlarged drawing of drawing 1.
[Drawing 3]Drawing of longitudinal section showing the second example of this invention.
[Drawing 4]The B section enlarged drawing of drawing 3.
[Drawing 5]Drawing of longitudinal section showing the third example of this invention.
[Drawing 6]The C section enlarged drawing of drawing 5.
[Drawing 7]Drawing of longitudinal section showing the fourth example of this invention.
[Drawing 8]Drawing of longitudinal section showing the fifth example.
[Drawing 9]Drawing of longitudinal section showing the sixth example.
[Drawing 10]Drawing of longitudinal section showing the seventh example.
[Drawing 11]Drawing of longitudinal section showing the eighth example.
[Drawing 12]Drawing of longitudinal section showing the ninth example.
[Drawing 13]The D section enlarged drawing of drawing 12.
[Drawing 14]Drawing of longitudinal section showing the stationary energy storage apparatus incorporating the 1st example of the magnetic bearing device known from the former.
[Drawing 15]Drawing of longitudinal section showing the 2nd example of the magnetic bearing device known from the former.
[Drawing 16]Drawing of longitudinal section showing the 3rd example.
[Description of Notations]
1 Vacuum housing
2 Axis of rotation
3 Holding pipe
4 Magnetic ring
5 Electromagnet
6 Active mold magnetic bearing
7 Rotor
8 Stator
9 Dynamo combination motor
10 Flywheel
11 Permanent magnet
12 Cooling jacket
13 Superconductor
14 Superconductivity thrust magnetic bearing
15a and 15b Yoke
16 Housing
17a and 17b Magnetic bearing unit
18 Permanent magnet
19 Back yoke
20 and 20a magnetization coil
21 Position transducer
22 Flange
23 Magnetic bearing unit
24 Yoke

25 Steel plate
26 Housing
27 Circular hole
28, 28a, 28b, and 28c Magnetic bearing unit
29 Top plate section
30a, 30b, 30a', and 30b' Permanent magnet
31 Back yoke
32 Magnetization coil
33 Crevice
34 Displacement sensor
35 The second magnetic bearing unit
36 The second back yoke
37 The second magnetization coil
38 Spacer
39 Bottom plate part
40 Permanent magnet
41 Back yoke
42a and 42b Unit
43 Superconductivity magnetic bearing
44a and 44b Permanent magnet
45a and 45b Back yoke
46a, 46b permanent magnet unit
47 Superconductor
48 Body
49 Controlled type radial magnetic bearing
50 Rotor
51 Electromagnet
52 Displacement sensor
53 Circular hole

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[Translation done.]

* NOTICES *



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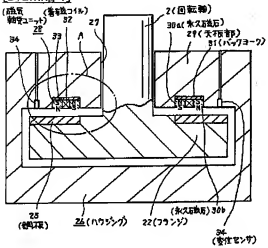
## DRAWINGS

[Drawing 1]

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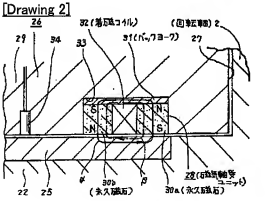


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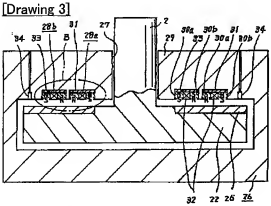


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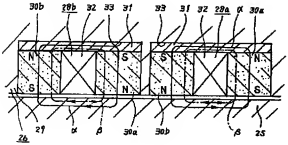

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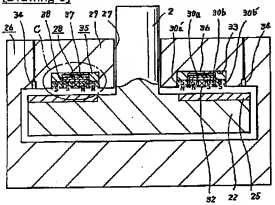

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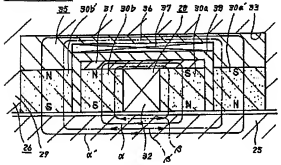

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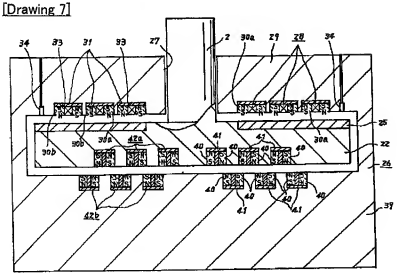

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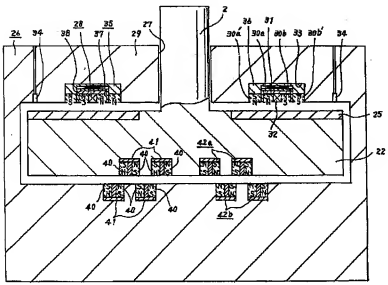

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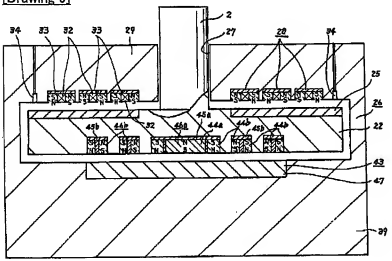

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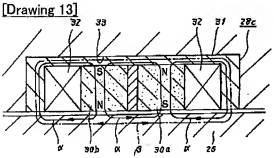

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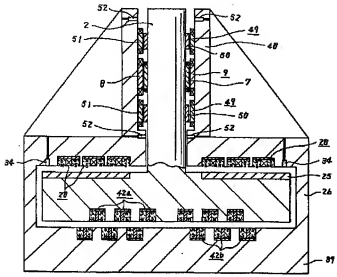


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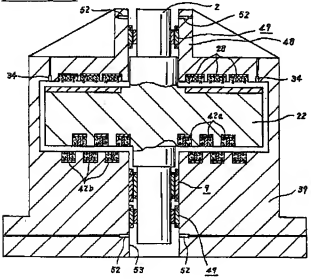


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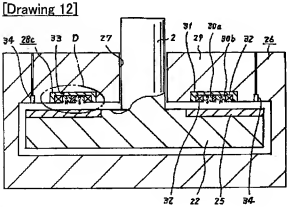


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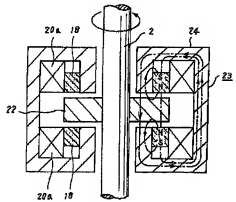


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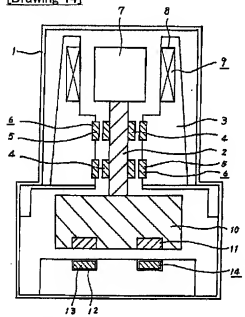
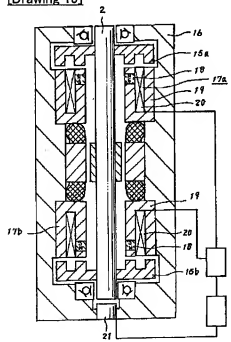



[Drawing 15]



[Translation done.]